SUBSTRATE SUPPORTING VIBRATION STRUCTURE, INPUT DEVICE HAVING HAPTIC FUNCTION, AND ELECTRONIC DEVICE

CROSS REFERENCES TO RELATED APPLICATION

[0001] The present application claims priority to Japanese Patent Application JP 2006-309543 filed in the Japanese Patent Office on Nov. 15, 2006, the entire contents of which is being incorporated herein by reference.

BACKGROUND

[0002] The present application relates to a substrate supporting vibration structure, an input device having a haptic function, and an electronic device, which are advantageously applied to an information processing device, mobile phone, personal digital assistant, or the like which gives a haptic stimulus to an operating body when selecting an icon or the like on the display screen for input item selection and inputting information.

[0003] More particularly, the present application is to provide a vibration substrate having a piezoelectric element at a predetermined position of a spacer member, fixed between two substrates, having a pillar form and/or a long strip form, and a vibration supporting portion and a vibration applying portion of the piezoelectric element disposed in the substrate supporting direction. The vibration substrate has rigidity that reduces a dimensional change caused due to bending stresses or torsion stresses. In addition, when the piezoelectric element is vibrated, the vibration substrate can surely achieve high reliability with respect to the vibration transmission, irrespective of the position of the vibration substrate being used.

[0004] In recent years, users or operators have various kinds of content introduced into mobile terminal devices, such as mobile phones and personal digital assistants (PDAs), and utilize them. These mobile terminal devices individually have an input device. As the input device, generally, a keyboard, an input means such as a JOG dial, a touch panel having a display unit, or the like is used.

[0005] An input-output device combined with a piezoelectric actuator has also been developed. The piezoelectric actuator comprises two or more stacked layers of piezoelectric elements having different strain amounts or a piezoelectric element and a non-piezoelectric element which are stacked, and bending deformation of the stacked material caused due to the difference between the strain amounts when applying a vibration control voltage to the piezoelectric element in the stacked material is mechanically utilized (vibrator function). It has been known that, conversely, when force is applied to the piezoelectric element, the piezoelectric element generates a voltage (force detecting sensor function).

[0006] As the actuator, a so-called bimorph actuator, unimorph actuator, disk actuator (hereinafter, these are collectively referred to simply as "piezoelectric actuator"), or the like is frequently used. The piezoelectric actuator is classified into a piezoelectric actuator of a multilayer structure and a piezoelectric actuator of a single layer structure, and, generally, the piezoelectric actuator of a single layer structure has a driving voltage as high as 50 V or more, and is not suitable for electronic devices, especially mobile devices.

[0007] With respect to the electronic device having a piezoelectric actuator of this type, an input-output device and an electronic device are disclosed in Japanese Patent Application Publication (KOKAI) No. 2004-94389 (FIG. **4**, page 9) (Patent Document 1). This electronic device has an input-output device having a bimorph-type piezoelectric actuator and a touch panel. The piezoelectric actuator is disposed between a display device and the touch panel, and gives different haptic stimuli to a user through the touch panel according to the type of vibration control data. The input-output device has a touch panel supporting structure in which the piezoelectric actuator is attached to a support frame.

[0008] FIG. **18** is a cross-sectional view showing a related art touch panel supporting vibrator **500**. The touch panel supporting vibrator **500** shown in FIG. **18** is seen in the patent document 1, and display means **29** and a touch panel **24** are disposed on a body substrate **501**. A part fitting space **102** is defined between the touch panel **24** and the display means **29**. Piezoelectric actuators **125** are mounted in the part fitting space **102** respectively at the four corners of a non-display region around the display region of the display means **29**. Under each piezoelectric actuator **125** are formed supporting portions **106** and **107** constituting vibration supporting points.

[0009] Thus the four piezoelectric actuators **125** are disposed in the respective four corners on the display means **29**. An applying portion **108** constituting a vibration applying point is formed on the piezoelectric actuator **125** at the middle. The applying portion **108** is composed of a separate component, and attached onto the piezoelectric actuator at the middle and pressed against the touch panel **24**.

[0010] The touch panel **24** is supported by the four applying portions **108**, and a panel press frame **104** presses the perimeter of the upper portion of the touch panel **24** through a dust seal **105**. The panel press frame **104** has at its top a bent portion having a reverse L-shaped cross-section. The panel press frame **104** is fixed to the body substrate **501** by, for example, a screw **109**. A wiring **103** is connected to the piezoelectric actuator **125**, and drawn through an opening portion formed in the panel press frame **104**.

[0011] In the touch panel supporting vibrator **500**, when a vibration control voltage is fed to the four piezoelectric actuators **125** through the wiring **103**, vibration can be transmitted to the touch panel **24**.

SUMMARY

[0012] By the way, when the structure of the touch panel supporting vibrator **500** disclosed in the patent document 1 is employed in an electronic device, such as a related art information processing device, mobile phone, or personal digital assistant (mobile device) having a haptic input function, the following problems occur.

[0013] i. When the touch panel supporting vibrator **500** held in a horizontal position is used, the touch panel **24** is supported by the four piezoelectric actuators **125**. However, when the touch panel supporting vibrator **500** held in a vertical position or slanting position is used, the touch panel **24** is inevitably supported only by the bonding force of the supporting portions **106** and **107**, the applying portion **108**, or the like.

[0014] For this reason, there is a possibility that, when the touch panel **24** shifts from the display means **29** or the bond-